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RESEARCH ARTICLE

Zigbee Based Communication System for Future Micro-Grids Using Http and MQTT Protocols

[*]S.Mounica[1], Dr. Sandeep Kumar[2]
[1] P.G. Student, Department of Electronics and Communication Engineering,
[2] Professor, Department of Electronics and Communication Engineering,
Sreyas Institute of Engineering & Technology, Hyderabad - 500068, India.

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ABSTRACT

A Micro-Grid (MG) is interconnected with different types of energy resources such as photovoltaic, wind energy, biomass, small hydroelectric generator and fossil fuel and so on. In order to have proper coordination among these resources within microgrid requires good communication to meet the load demands. Therefore, a wireless data communication system for future microgrids is presented in this paper. It is assumed that each MG has a central controller and each Distributed Generation (DG)unit in the MG has a local controller. The communication system is responsible for transmitting and receiving data amongst these controllers. This communication system is based on Zigbee technology, which is a low cost and low power consumption device. An IOT module is included to update the information related to the electrical parameters of DG. Approaching the IOT, protocols used for data communication from the central controller to DG are MQTT and HTTP. Among these two protocols which one transfers the fluctuated data within less time from the central controller to DG in-order to stabilize the load is observed.

Keywords: Zigbee, Micro-Grid, MQTT, HTTP.

1. INTRODUCTION

Renewable energy resources such as photovoltaic, wind, and micro-hydro are main factors for electric energy generation in the form of distributed generation (DG) units within the electric networks. Integration all the DG's of a network will result in many benefits like cost reduction, power loss reduction in long feeder networks which results in their liability of the network. If this integration is implemented Fault in the feeder networks can be known very fast and certain precautionary measures can be taken before it gets totally damaged. Combination of loads, DGs, and energy storages which are interconnected by a network of feeders located in the same geographical area can be called as a Microgrid. By using the data transfer techniques in Microgrids we can monitor all the parameters coming from different DG's within a Microgrid can be monitored. If we add some more technology like "Internet of Things" (IOT) more reliable transfer of data from one micro located in a geographical area to another Microgrid in another geographical area can be achieved, hence all the microgrids across the country will be talking to each other which results in increased reliability of the electrical networks. The main concept of this work

*Corresponding author. Tel.: +919441075578
Email address: drsandeep@sreyas.ac.in (Sandeep Kumar)
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is to analyze which is the best protocol that can be employed for data transfer between one DG unit in an MG to other DG in another MG. The electrical parameters like network voltage, current, and power supplied by each DG is transferred from local controller to central controller. If there is any mismatch in the transferred parameters controlling action can be done through Wi-Fi communication. Therefore, for proper operation and control of DGs within an MG, each DG should be updated with the information about the electrical parameters of DG. This information is required to be transferred from one MG to other MG. Furthermore, instantaneous values of voltages at the terminals of DGs and the feeder are needed for synchronizing a new DG with the Network. By doing this kind of data transfer we can expect that all the operations in an MG will be fully automated in the near future [1]. The presented paper is based on communication or data transfer between all the microgrids through wireless sensor networks in future. Basically, there will be a number of microgrids with distribution units within them. Each Micro Grid has a central controller and the distribution units have a local controller. Data transfer between these controllers is based on Zigbee communication. Zigbee is a low-cost and low power consumption module. The controlling and data transfer between one MG to other MG based on Wi-Fi communication. We use HTTP protocol and MQTT protocol and showcase which is the best protocol for data transfer based on time consumed for data transfer within grids. A comparison of the characteristics of the MQTT protocol and HTTP wireless sensor networks in future. Basically, there will be a number of MGs with distribution units and each MG has a central controller and the distribution units have a local controller. Data transfer between these controllers is based on Zigbee communication. Zigbee is a low-cost and low power consumption module. The controlling and data transfer between one Micro-Grid to other microgrid is based on Wi-Fi communication. We use HTTP protocol and MQTT protocol and which is the best protocol for data transfer based on time consumed for data transfer within grids. A comparison of the characteristics of the MQTT protocol and HTTP protocol is achieved in this proposed work. Fetching Data from sensors, passing the data to the controller and finally passing the controlling commands will make the automation of the future MGs.

2. LITERATURE SURVEY

The demand for interconnected and wireless sensor networks increasing day by day in the world. These interconnected wireless networks are used for remote controlling of all the home automation systems, video systems [2]. These are also used for fetching the data from sensors, transferring the fetched data to other systems making them as smart systems. The new technology "Internet of Things" has gained lots of importance for connecting different devices in billion ways. This particular vision of integrating things leads to many challenges like sufficient power and throughput for transferring or exchange of data between IOT channels. There is one wireless communication standard which shows its significance in achieving these challenges which are called as Zigbee standard. The Zigbee is designed in such a way to have specifications like low data rate, low power consumption. This Zigbee standard is based on IEEE 802.15 protocol, the main advantage of this protocol is it uses a mesh network for transmitting or receiving the data to provide a reliable, simple, and low-cost solution for maintaining long battery life [2]. As it has low power consumption the data transmission distance is limited to a shorter range, but as it can operate with mesh network the transmission distance can be relatively increased to longer range. The two main factors that are used for evaluating a protocol is its throughput and energy consumption. The rate of successful data transmission is measured by throughput. This measurement can provide valuable information about the amount of data that can be transferred at a particular instance of time. As the Zigbee Standard is having low power, its energy consumption is used for assessment of its performance which intern determines the lifetime of battery powered [3] devices.

3. PROPOSED METHODOLOGY

The proposed system is basically performed with two techniques of Zigbee communication. Each technique is categorized into different layers. The two techniques used is based on HTTP protocol along with Zigbee communication and MQTT protocol along with Zigbee Communication [4]. In each of technique, we can calculate the speed of data is transmitted from one DG to other DG. At the

end, the most reliable and fast technique for data transmission is categorized.

The following steps of the methodology are shown in Figure 1:

- XBEE
- Current sensor
- Potentiometer
- Node MC
- Servo motor

XBEE: Xbee is a radio module from Digi International used for data transmission. These radio modules are introduced under Max Stream brand in 2005 these radio modules are based on IEEE 802.15.4-2003. These are designed in such a way that they can be operated in a different type of network topologies like start mesh point to point with a baud rate of 250 Kilobytes per second.

Current Sensor: It is an accurate sensor to measure AC/DC current up to 5A. It has the capability of measuring high AC mains current and is still isolated from the measuring part due to integrated hall sensor. It works under the principle hall effect. ACS712 current sensor operates from 5V and outputs an analog voltage proportional to current measured on the sensing terminals such as microcontroller ADC to read the values [6].

Potentiometer: The potentiometer is an electronic device whose resistance can be adjusted manually. The amount of current flowing through the circuit is controlled by increasing or decreasing the value. It can be used as volume knob in music systems, or as fan regulators etc.

The strips of Potentiometer are made based on resistivity and conductivity. Potentiometer resistance is varied through resistive strip which is made of carbon. Conductive strip helps the potentiometer to carry the current into the circuit in accordance with the resistance [5].

Node MCU: Node MCU is also referred as ESP8266 Wi-Fi chip it is the 12 version in Wi-Fi chip family and is called as ESP826612E. This board can act as station mode and access point mode. Station mode is nothing but it gets connected to the available Wi-Fi networks. Access point mode can act like hotspot so other devices can get connected to this module. The Wi-Fi Communication works under the IEEE standard 802.11 b/g/n protocol.

Specification:

- Microcontroller used on Node MCU board is ESP-8266EX
- Operating Voltage for Node MCU is3.3V
- It has 11 Digital Input Output Pins
- It plays a vital role in wireless sensor networks[9].
- As the Zigbee can operate even in mesh networks the data is transmitted through longer distances as quickly as possible.

Servo motor: An electrical device which is used to push or rotate an object with great precision is called as Servo Motor. Servo motor is used to rotate an object at some particular angle or to some distance. The simple motor which runs through servo mechanism is used to design a servo motor. If the motor used is AC motor then it is called AC servo motor, if the motor used is DC motor then it is called a DC servo motor. Very high torque servo motor which is of small size and light weight packages are available in the market. As it is used to rotate an object or move any object these are

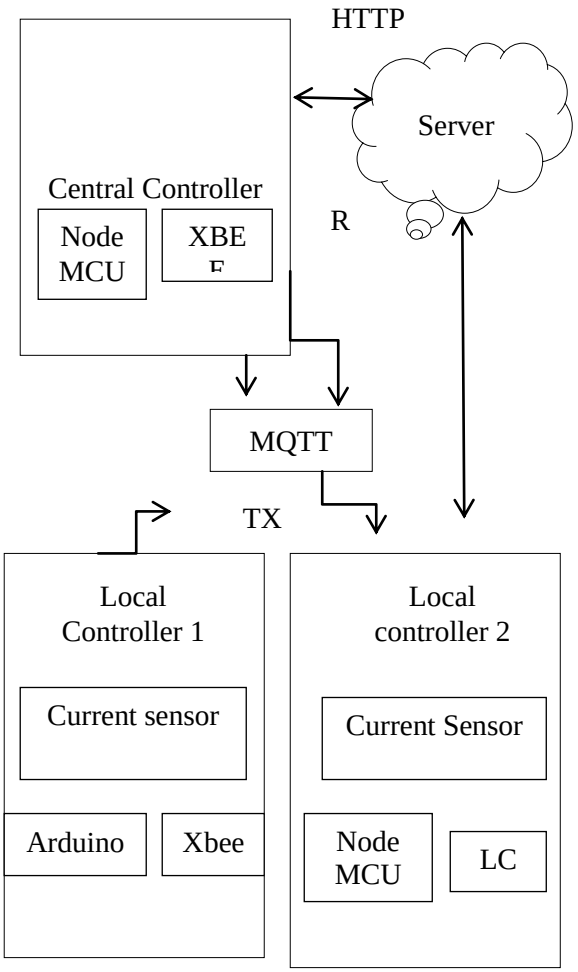

Figure 1: Block Diagram of Proposed Methodology

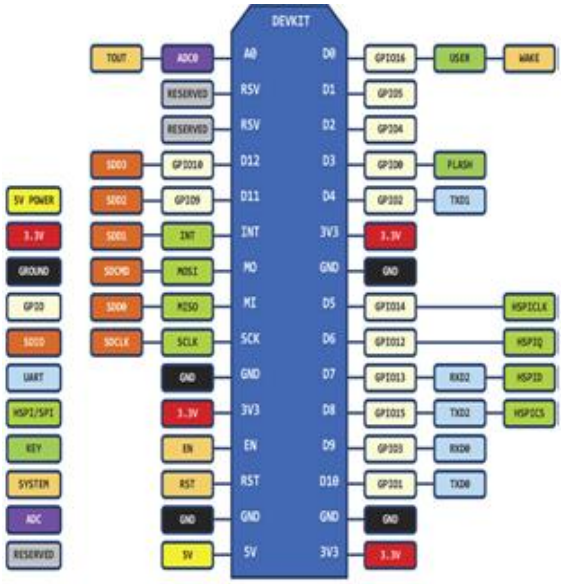

Figure 2: Node MCU pinout [8].

used in many applications like a toy car, RC helicopters, and planes, Robotics, Machine etc[6].

LCD display: Liquid crystal is the abbreviation of LCD. Combination of two states of mater namely the solid and the liquid is an LCD. It has two rows which can accommodate characters in each row. The backlight on the LCD screen is provided by LED. If you power up the LCD screen you can see the rectangles in which characters are placed and also can view the pixels that make up each character. You can see the rectangles for each character on the display and the pixels that make up each character. This LCD works under the principle that whenever any current is applied to liquid crystal molecules they tend to untwist which results in a change in light angle passing through these crystal molecules. The change in light angle passing through crystal intern changes the angle of the top polarizing filter. As the light angle falling on the top polarizing filter changes little amount light is passed through that particular area of LCD. Thus that area becomes darker comparing to others [7].

Arduino: The Arduino is a prototyping board equipped or integrated with different electronic devices. The heart of this board is a microcontroller which is called asATmega328. The other parts of this boards are general purpose input output pins, a crystal oscillator, a USB connection, a power jack, ICSP header, reset button. It contains everything that a system should have. Arduino required software through which, we can dump the program

easily. It is the best board used for prototyping because Arduino has a driver circuitry through which, we can dump the program in Microcontroller with USB cable. This driver circuitry is programmed in such a way that it acts like a USB to Serial converter. There are many different Arduino boards. The name UNO is given to this because this is the first board introduced and "Uno" means one in Italian. The Uno is the latest in a series of USB Arduino boards as shown in Figure 2.

Specifications

- The microcontroller used on the board is ATmega328.
- It operates under 5V.
- Input voltage ranges between 7-12V.
- It has 14 digital Input Out pins.
- It has 6 analog input pins and 6 analog output pins termed as PWM pins. [8]

4. RESULTS& DISCUSSIONS

I. Analysis for Technique1 using HTTP

- According to Figure1, the first technique has three layers. Following mentioned points are the results and testing done, during an experiment performed with the entire system.

Testing of layer 1 in technique 1

- The Zigbee router must be connected to the DG1 (local controller) during the transfer of the data from the local controller in API mode to central controller in AT mode [7].
- The below Figure 3 shows that transmission has successfully completed to the central controller. The parameters transmitted are
    - Voltage
    - Power
    - Current

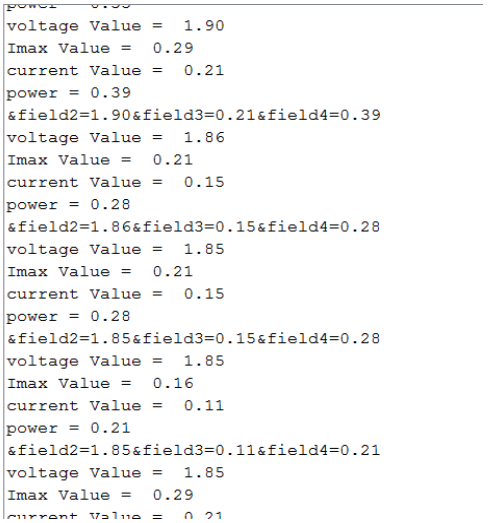

Figure 3: Testing of layer 1 of HTTP

Testing of layer 2 in technique1

- This testing is done during the data is transferred from central controller to server.
- The microcontroller used in central controller unit is ESP826612E which works as a device that connects to available Wi-Fi networks.
- Data coming from layer1 is transferred to the server with the help of HTTP protocol.
- The Figure 1 shows that the data is successfully transmitted from central control to the cloud. The parameters that got transmitted to the cloud are:
    - Voltage
    - Power
    - Current

Testing of layer 3 in technique 1

- In this section testing of data communication from layer 2 to layer 3 is done.
- Here the data that is visualized on the cloud is sent back to the DG2

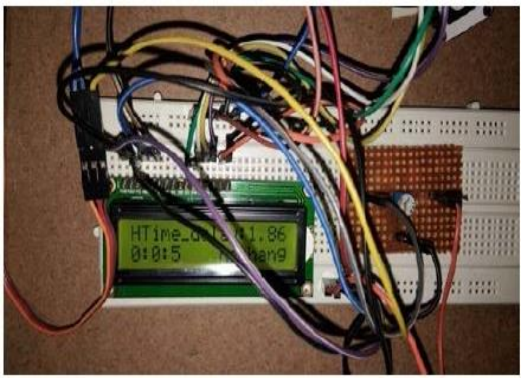

Figure 4: Testing of layer 3 of HTTP protocol

- Whole time calculation that required for communication between layer 1 to layer 3 and layer 3 is computed in the section and displayed on the LCD screen.

II Analysis for Technique 2 using MQTT

- According to Figure1, the second technique has two layers. Following points are the results and testing done while experiment performed. This entire section will give the results of data communication from first layer 1 (i.e. data communication from DG1 to central controller) to layer 2 (data communication from MQTT broker to DG2).

Testing of layer1 in technique2

- The Zigbee router must be connected to the DG1 (local controller) during the transfer of the data from local controller in API mode to central controller in AT mode
- The Figure 4 shows that transmission has successfully completed to the central controller. The parameters transmitted are
    - Voltage
    - Power
    - Current and time stamp

```
Transfer-Encoding: chunked
Content-Type: text/html; charset=UTF-8

14
Successfully updated
0

 Date:21.8.2017
&field1=10:21:21&field2=1.86&field3=0.15&field4=0.28
connecting to microgrid.thesmartbridge.com
key=40719133639&field1=10:21:21&field2=1.86&field3=0.15&field4=0.28
HTTP/1.1 200 OK
```

Figure 5: Testing of layer 2 of HTTP protocol

Testing of layer 2 in technique 2

- In this section testing of data communication from layer1 to layer2 is done protocol displaying on LCD.

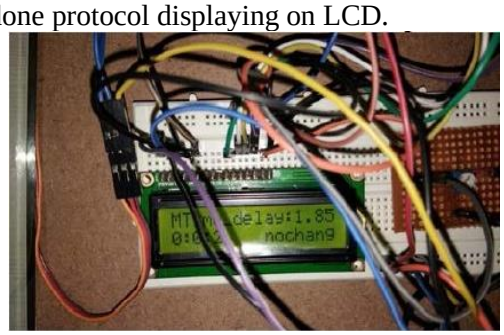

Figure 6: Testing of layer 2 in MQTT protocol.

- Here the Broker takes a crucial role in transmitting data from the central controller to the DG2.

The main aim of this methodology is consumption of time during data transmission with technique 1 and technique 2. With the MQTT protocol time required for data transmission is in microseconds as shown in figure 4 and HTTP protocol the time taken was in minutes as shown in figure 6. So it was concluded that for high data transmission MQTT protocol will be better than the HTTP protocol. The HTTP is a client and server-based protocol and both the protocol will not be connected every time. So the time has taken for connectivity of server and client is more in HTTP protocol. On the other hand, the data transmission is fast in MQTT because it is based on publisher and subscriber protocol where publisher and subscriber will be connected all the

time. Once the data transferred from publisher instantly it will send to the subscriber. Whole time calculation that required for communication between layer 1 to layer 2 is computed in the section and from the above testing analysis the following results can be achieved:

- It was concluded that Zigbee is a device which is a low cost and low power consumption device. From this conclusion, we can say that Zigbee plays a vital role in wireless sensor networks [9].
- As the Zigbee can operate even in mesh networks the data is transmitted through longer distances as quickly as possible
- By using MQTT protocol the data got transmitted to other DG within micro or milliseconds. Hence we can say that for data transmission in MGs, MQTT protocol will be the appropriate protocol.

V. CONCLUSIONS

From the testing results and analysis, the following points will be concluded. It was concluded that Zigbee is a device which is a low cost and low power consumption device. From this conclusion, we can say that Zigbee plays a vital role in wireless sensor networks. As the Zigbee can operate even in mesh networks the data is transmitted through longer distances as quickly as possible. Here we are using two techniques for data transmission from the above testing analysis it was concluded that HTTP protocol takes more time for transmitting the data. It will take some seconds to transmit the data. We cannot say this is a bad technique but the areas which require a high speed of data transmission HTTP protocol is not suggestible. By using MQTT protocol the data got transmitted to other DG within micro or milliseconds. Hence we can say that for data transmission in MGs, MQTT protocol will be the apt protocol.

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